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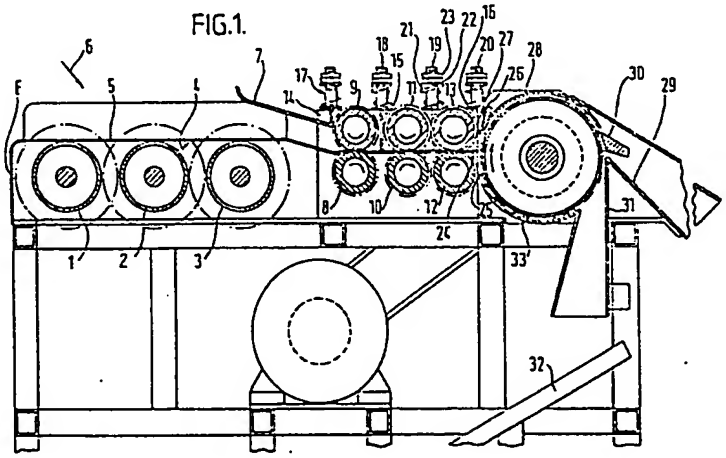
(54) Separation of fibres from vegetable matter.

(57) Apparatus for extracting fibres from a fibre containing plant material has a set of pinned rollers (1, 2, 3) having pins (4) co-operating with a slotted grid (5) along which the plant material travels, the pins (4) aligning the plant material. Crushing rollers (8, 9, 10, 11, 12, 13) tend to separate the fibres from the unwanted bark and other pith-like "chiv" in the plant material and a rotatable pinned roller (25) downstream of the crushing rollers (8, 9, 10, 11, 12, 13) combs out fibres from the crushed, aligned plant material.

FIG.1.



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SEPARATION OF FIBRES FROM VEGETABLE MATTER

This invention relates to the separation of fibres from vegetable matter and in particular, to the decortication and cleaning of flax straw, so as to produce a basically fibrous end product.

It has been known for many years that an inclusion of flax fibre in paper pulp greatly enhances the strength and quality of the paper. Until recently this fibre has been obtained by tearing up used linen table-cloths, bed sheets, etc., but this is becoming more difficult as pure linens are increasingly adulterated with other fibres, particularly man-made fibres, which are unacceptable in paper. In addition, there is a desire to up-grade paper quality in many instances and thus there is an unfulfilled demand for considerable quantities of cheap, low grade flax fibre for papermaking. Furthermore, asbestos fibres have now been shown to provide a health hazard, and it has been found that flax fibres provide a most acceptable alternative.

Flax is widely grown commercially both for the fibre in the stem which is processed into linen and for other uses, and for the valuable seed which is the source of Linseed oil.

Generally speaking, at present, different strains of the flax plant are grown depending on whether fibre or seed is of economic importance. Tall growing strains are important for fibre production, especially for line flax, while short plants mature earlier and are cheaper to grow if only the seed is of economic importance.

It is also the case that flax for fibre is normally harvested before the seed is fully mature. It has been traditionally felt in Northern Europe that allowing the plant to stand in the field in a moist temperate climate while the seed ripens increases the risk of the flax being damaged by autumn rain and wind, making the task of pulling or harvesting difficult.

Flax for seed is also grown in areas where a long dry autumn allows certain ripening of the seed with little or no risk of weather damage.

The processing of flax straw into fibre (retting) has traditionally involved the use of large amounts of water. Usually only 20% or 30% by weight of the straw is liberated as usable fibre and it is therefore usually not economically viable to transport the straw over great distances to centralised retteries. This also explains why linen products are so expensive.

For these reasons, in large areas where flax is grown for seed, no attempt is made to save any fibre. It would be uneconomic to attempt to produce flax fibre in the traditional way, using water and involving many handling operations, even though this gives a very strong, high quality fibre. Therefore there is an obvious opening for a fibre which is a by-product obtainable from flax already being grown in large quantities, e.g. in Canada and the United States of America, for linseed oil on a profitable commercial basis.

The normal practice at present is to burn the flax straw in the field after harvesting the linseed, and then plough. However, about 80-90% of the nutrient value of the plant matter is lost by burning, together with the loss of the soil-conditioning properties of the vegetable matter.

It is not practical to plough back the harvested straw as it comes from the machines as, in bulk and in the long lengths, it takes several years to break down under the action of soil organisms in the prevailing climate which tends to be dry for a period of months in summer.

There is no doubt that there is a demand for low to medium quality flax fibres provided they can be produced relatively cheaply. In addition to textile uses, the fibres are, for example, useful in high quality writing paper, bank note paper, cigarette paper, etc., and as a replacement for asbestos fibres in corrugated roofing panels, etc.

The purpose of this invention is to provide a method and apparatus for separating fibres from other matter in straw, and more especially, to provide a flax decorticating and cleaning machine which can, if required, be fitted as an attachment to a mobile threshing machine, combine harvester or pick-up baler.

It will be appreciated, however, that the method and apparatus need not be limited to use in handling flax straw. It could have other fibre extracting uses, and would be especially suited to handling straw from jute, hemp, Kenaf, sisal and other plants containing bast fibres.

According to the broadest aspect of the present invention, we provide apparatus for extracting fibres from a fibre containing plant material comprising means for aligning the plant material so that the fibres contained therein are generally in alignment with their path through the apparatus, crushing means tending to separate the fibres from the unwanted bark and other pith-like "chiv" in the plant material, and separating means downstream of the aligning and crushing means, comprising a pinned roller rotatable about its axis, preferably within a shroud spaced from but generally conforming with the surface of rotation of the roller, to comb out fibres from the crushed aligned plant material, there being first and second discharge means associated with the shroud for chiv and fibres respectively.

Hereinafter, the invention will be described with reference to the extraction of fibres from flax straw, but it will be appreciated that this is only by way of example, and is not intended to be limiting.

By a pinned roller, we mean a roller, the surface of which has a plurality of closely arranged pointed pins or the like projecting generally uniformly therefrom; of course, as is well known in the hacklemaking art, various pinning patterns may be used, and instead of pins providing the combing surface of the roller,

card wire or equivalent means may be used.

Preferably, the means for aligning, crushing means, and pinned roller and shroud are provided in three separate operating zones. At the first zone, a train of coarsely pinned rollers co-operating with a slotted grid and arranged to rotate at progressively increasing speeds is provided to align, e.g. roughly parallelise, the flax straw.

Preferably, at the second operating zone, the roughly parallelised straw is then fed directly to the crushing means which may consist of a plurality of pairs of co-operating spring-loaded rollers. These rollers may be plain but are preferably fluted. These pairs of rollers are also arranged to have a progressively faster surface speed to continue the preliminary alignment of the flax straw. They also serve to crush the non-fibrous components of the straw to allow easy separation of the fibrous material from the woody and pith-like "chiv".

Preferably, the partially aligned and crushed flax straw is then presented by the last pair of crushing rollers to the third operating zone where the densely pinned roller, which revolves rapidly, teases out the fibres and mechanically separates the brittle and loosely adhering chiv from the tougher and more flexible fibre. Separating edges are preferably also provided to divide the liberated chiv from the fibrous material.

The fibre can then be collected on a conveyor and subsequently baled in an attached or adjoining baling machine.

A separate shaking screen device can be provided to liberate further amounts of entrained but mechanically separated chiv particles from the fibrous mass.

Additional cleaning and chiv liberating effect can be achieved by using a fixed concave pinned plate co-operating with the fin pinned roller and/or by the use of pinned stripper and worker roller pairs

or redirecting rollers, which may be located above the densely pinned roller.

Preferably, the apparatus is a mobile device which operates in the field where flax is grown. In order to ensure the satisfactory threshing action on the flax straw, it is normal practice to cut the standing flax and leave it lying in the field for a period of days to complete drying out. This swathe is then lifted by a mobile thresher and the straw is dropped back on to the field. In accordance with current practice, the straw is then burned and the field ploughed and prepared for the next crop. The decorticating machine, in accordance with this present invention, can be fitted to the rear of the mobile thresher.

Alternatively, especially if the flax is grown for its seed, it can be harvested by a combine harvester, in which case the apparatus of this invention can be fitted to the combine harvester to separate fibres from the straw normally emitting from the rear of the harvester.

Preferably, the straw, after simple cutting or harvesting by combine harvester, is allowed to lie in the field for a further period of days to continue drying and dew retting, i.e. it is allowed to decompose partly due to atmospheric conditions, before being picked up by a baling machine, to which the apparatus of this invention is fitted. In this way, just the fibres, plus some chiv, is baled, and the majority of chiv is returned to the ground to be ploughed in subsequently.

Also according to the present invention, we provide a method of separating fibres from vegetable matter, e.g. flax straw, wherein the vegetable matter is subjected to crushing and alignment operations, and is then subjected to a combing operation with a pinned (as hereinbefore defined),roller, to separate fibres from the remainder of the vegetable matter.

Two embodiments of apparatus for separating fibres from flax straw are now described by way of example only with reference to the accompanying drawings, wherein:-

FIGURE 1 is a longitudinal section showing the relationships of the rollers in an embodiment of the invention using three pinned feed rollers and three pairs of fluted crushing rollers, and a pinned combing roller for separating out fibres, and

FIGURE 2 shows a part-section of a modification of the Figure 1 embodiment, wherein an additional pair of fluted redirecting rollers is provided.

Referring to Figure 1, three pinned aligning rollers 1, 2. and 3, each of which is coarsely pinned with pins, only one of which, 4, is shown, are mounted for rotation about horizontal axes in a frame F. As the rollers 1, 2, 3, rotate, the pins pass through a slotted grid or straw receiving plate 5 which supports the flax straw which is fed onto the grid from the direction of the arrow 6. The rotational speed of the rollers 1-3 is arranged to be progressively faster so that the second roller 2 turns faster than the first roller 1, and the third roller 3 turns faster than the second roller 2. Thus a drawing and parallelising action on the flax straw occurs at this stage.

A cover plate 7 is provided to help to control the flax straw which is then fed into the nips of a series of three pairs of crushing rollers 8, 9; 10, 11; and 12,13. These rollers are preferably fluted. The lower rollers 8,10 and 12 are driven at progressively higher speeds to continue the drawing and parallelising action.

The top rollers 9,11 and 13 are undriven and free to rotate. They are mounted for rotation about horizontal axes in blocks 14,15 and 16 controlled by compression devices 17,18,19,20 incorporating coil springs 21 supported on threaded shafts, and held in place by pre-tensioning

nuts 22 and lock nuts 23.

Preferably, the size of fluting on the rollers is also progressively finer to ensure that the brittle pith-like and woody matter in the flax straw is well broken up and as far as possible liberated from the fibres in the straw. In one peferred embodiment of the invention (not shown) the final pair of rollers are plain.

The crushed straw is fed from the nip 24 of the third pair of crushing rollers 12,13 to a rapidly rotating finely pinned roller 25 which rotates in the direction of the arrow A and carries out a combing or separating or beating action on the straw to separate the broken up particles of chiv, i.e. the woody and pith-like matter (which is not required) from the flax fibre. An adjustable blade 26 with a stripping edge 27 ensures that the straw does not get carried over the top of the last top crushing roller 13.

A fixed, curved shroud plate or shell 28 is provided to control the fibre being carried round by the roller 25. It is possible to increase the work done on the fibre by fitting inwardly pointing pins to the shell 28. A first discharge chute 29 is provided to convey a proportion of the liberated chiv to the rear of the unit where it falls onto the ground. A movable baffle 30 controls the exit opening to avoid flax fibre being ejected into the chute 29 at this point.

A second discharge chute 31 is provided by which the fibre is removed from the pinned roller 25. The fibre is allowed to fall onto an inclined vibrating grid 32 with a mechanical shaking device (not shown) which serves to separate more of the loose chiv from the fibre mass.

The fibres fall from the grid 32 onto a conveyor which may take them to an adjoining baler (not shown) which may be of any conventional type. An undercasing 33 is provided to control any fibre which may be carried round under the roller 25.

Figure 2 shows an optional modification of the apparatus to allow a controlled second beating action on the flax straw. The fixed shell 28 is replaced by shroud parts 28,28a and by secondary feed unit consisting of a cover 33a and a further pair of preferably fluted redirecting rollers 34,35. The fibre and chiv is thrown by the action of the pinned roller 25 over the roller 34 and is directed into and gripped by the nip 39 of the rollers 34 and 35, and is re-presented to the roller 25 for a second time.

A separating edge 36 on the shroud or cover plate 28a ensures that the material is predominantly passed into the second feed unit, and an adjustable blade 37 with a stripping edge 38 serves to stop the material being carried round the roller 35 as described hereinbefore.

Further chiv-loosening can be carried out on the fibre if the fixed shell 28 is pinned internally as described hereinbefore. Two discharge chutes are provided as in the previous embodiment.

In the embodiment illustrated in Figure 1, the dimensions and surface speeds of the various rollers are as follows:-

The three pinned feed rollers 1-3 are 5.75 ins. (14.6 cm) in diameter and are pinned with 15 rows of 45 pins each at 1.25 ins (3.175 cm) pitch with a projection of 1.375 ins (3.49 cm).

The three pairs of crushing rollers 9-13 are 3.75 ins. (9.525 cm) in diameter. The first pair have 28 teeth (0.42 ins or 1.066 cm pitch) and the second and third pair have 35 teeth (0.33 ins or .0838 cm pitch).

The pinned roller 25 has a diameter of 10.6 ins (26.924 cm) and is pinned with 200 rows of 352 pins each at 0.166 ins (.4216 cm) pitch with a projection of 0.120 ins (.305 cm).

The pinned feed rollers 1, 2 and 3 revolve at 20, 22 and 25 rpm giving a surface speed at the midpoint

of the pins of 37ft. per minute (.1887 metres/sec.), 41ft. per minute (.2091 metres/sec.) and 46ft. per minute (.2346 metres/sec.) respectively.

The crushing rollers 9-13 revolve respectively at 75, 85 and 99 rpm, giving surface speeds of 73, 83 and 97ft. per minute (.3723, .4233 and .4947 metres/sec) respectively. Because of the fluting, the material will be fed somewhat faster than this.

The speed of the pinned roller can vary between 600 and 2000 rpm, giving a surface speed varying from 1650ft. per minute to 5500ft. per minute (8.415 to 28.05 metres/sec).

It will be appreciated that the present invention results in the following advantages:

(a) A considerable reduction in the cost of producing low to medium grade flax fibre.

(b) A replacement fibre for asbestos can be provided at low cost.

(c) A fibre to replace the reclaimed fibre from pure linen used in paper making can be provided, resulting in improved quality paper.

(d) A method whereby flax can be decorticated on the farm and, preferably, in the field, thus reducing the residue to small particles which may be returned to the soil as a soil conditioner and fertiliser without burning is achieved.

(e) A commercial fibre which can be grown in temperate climates such as Europe (including the U.K.), Northern North America and Southern South America, can now be harvested economically.

(f) An additional cash crop is available for farmers.

(g) Conservation of humus and improved farming.

It can be seen that with linseed flax already a commercial crop, anything paid for the flax fibre after transport has been allowed for is additional

profit for the farmer. Transport costs will be reduced because only usable fibre will have to travel any distance and, if a mobile unit is provided, the residue (chiv) will fall back onto the field where it is wanted for humus.

As a guide to the scale which this project might assume, Canada has in excess of 2 million acres growing flax and the United States of America has around 1 million acres, with a yield of 2/4 tonnes of straw per acre. It is difficult to envisaged markets to absorb 1 million to 2 million tonnes of fibre but, as an example, Europe is pledged to ban the use of asbestos fibre by the end of 1984 and 60,000 to 80,000 tonnes of flax fibre could be required per annum in Europe solely for that purpose. This is on top of the requirements of the papermaking industry.

CLAIMS:

1. Apparatus for extracting fibres from a fibre containing plant material comprising means (1,2,3,4) for aligning the plant material so that the fibres contained therein are generally in alignment with their path through the apparatus, crushing means (8,9,10,11,12,13) tending to separate the fibres from the unwanted bark and other pith-like "chiv" in the plant material, and separating means (25) downstream of the aligning and crushing means, comprising a pinned roller (25) rotatable about its axis, to comb out fibres from the crushed aligned plant material.

2. Apparatus according to claim 1 wherein a train of coarsely pinned rollers (1,2,3) co-operating with a slotted grid (5) and arranged to rotate at progressively increasing speeds is provided to align, e.g. roughly parallelise, plant material.

3. Apparatus according to claim 1 or 2 wherein the roughly parallelised plant material is fed directly to the crushing means which consist of a plurality of pairs of co-operating spring-loaded rollers (8,9,10, 11,12,13).

4. Apparatus as claimed in claim 3 wherein the co-operating spring-loaded rollers (8,9,10,11,12,13) are axially or helically fluted.

5. Apparatus according to claim 3 or claim 4 wherein the pairs of crushing rollers (8,9,10,11,12,13) have a progressively faster surface speed.

6. Apparatus according to any preceding claim wherein partially aligned and crushed plant material is presented to the pinned roller (25) of the separating means, which revolves rapidly, teases out the fibres and mechanically separates the brittle and loosely adhering chiv from the tougher and more flexible fibre.

7. Apparatus according to any preceding claim wherein the pinned roller (25) rotates within a shroud (28)

spaced from but generally conforming with the surface of rotation of the roller (25) there being first and second discharge means (29,31) associated with the shroud for chiv and fibre respectively.

8. Apparatus according to claim 7 wherein the shroud (28) is wholly or partly replaced by a fixed concave pinned plate.

9. Apparatus according to claim 7 or 8 wherein a pair of pinned or toothed worker and stripper rollers replace part of the shroud, which worker and stripper rollers co-operate with the pinned roller (25).

10. Apparatus according to any one of claims 7-9 wherein at least one pair of redirecting rollers (34,35) is located above the pinned roller (25) of the separating means.

11. Apparatus according to claim 10 wherein the redirecting rollers comprise a further pair of spring-loaded rollers (34,35).

12. Apparatus according to any preceding claim wherein separating edges (30,36) are provided to divide the liberated chiv from the fibrous material.

13. Apparatus according to any preceding claim wherein separated fibre is collected on a conveyor.

14. Apparatus according to any preceding claim wherein a separate shaking screen device (32) is provided to liberate entrained but mechanically separated chiv particles from the fibrous mass.

15. Apparatus according to any one of the preceding claims, which is mobile, and is fitted to a mobile thresher or to a combine harvester, or to a baler or to another agricultural machine.

16. A method of separating fibres from vegetable matter, wherein the vegetable matter is subjected to crushing and alignment operations, and is then subjected to a combing operation with a pinned roller (25) to separate fibres from the remainder of the vegetable matter.

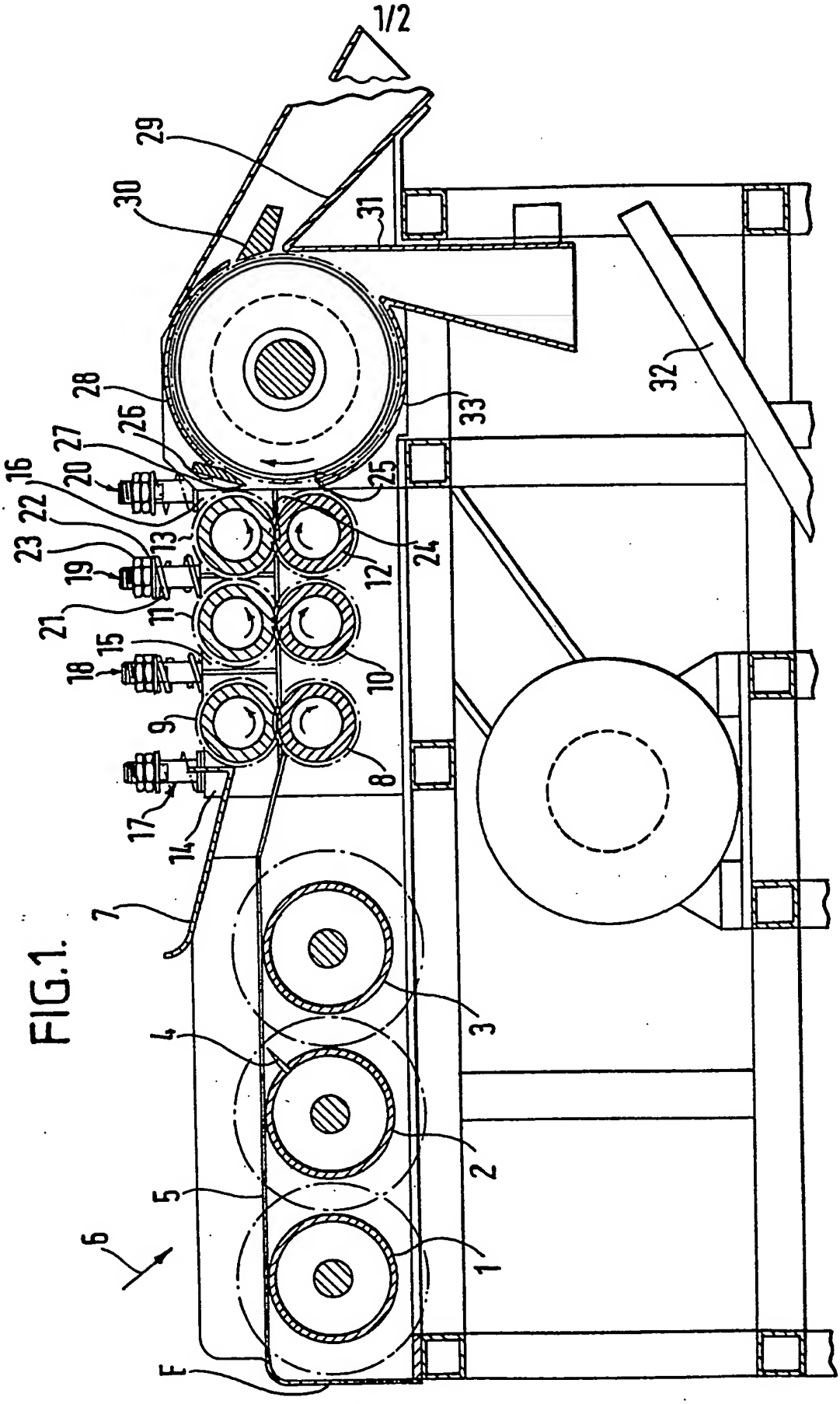
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FIG.1.

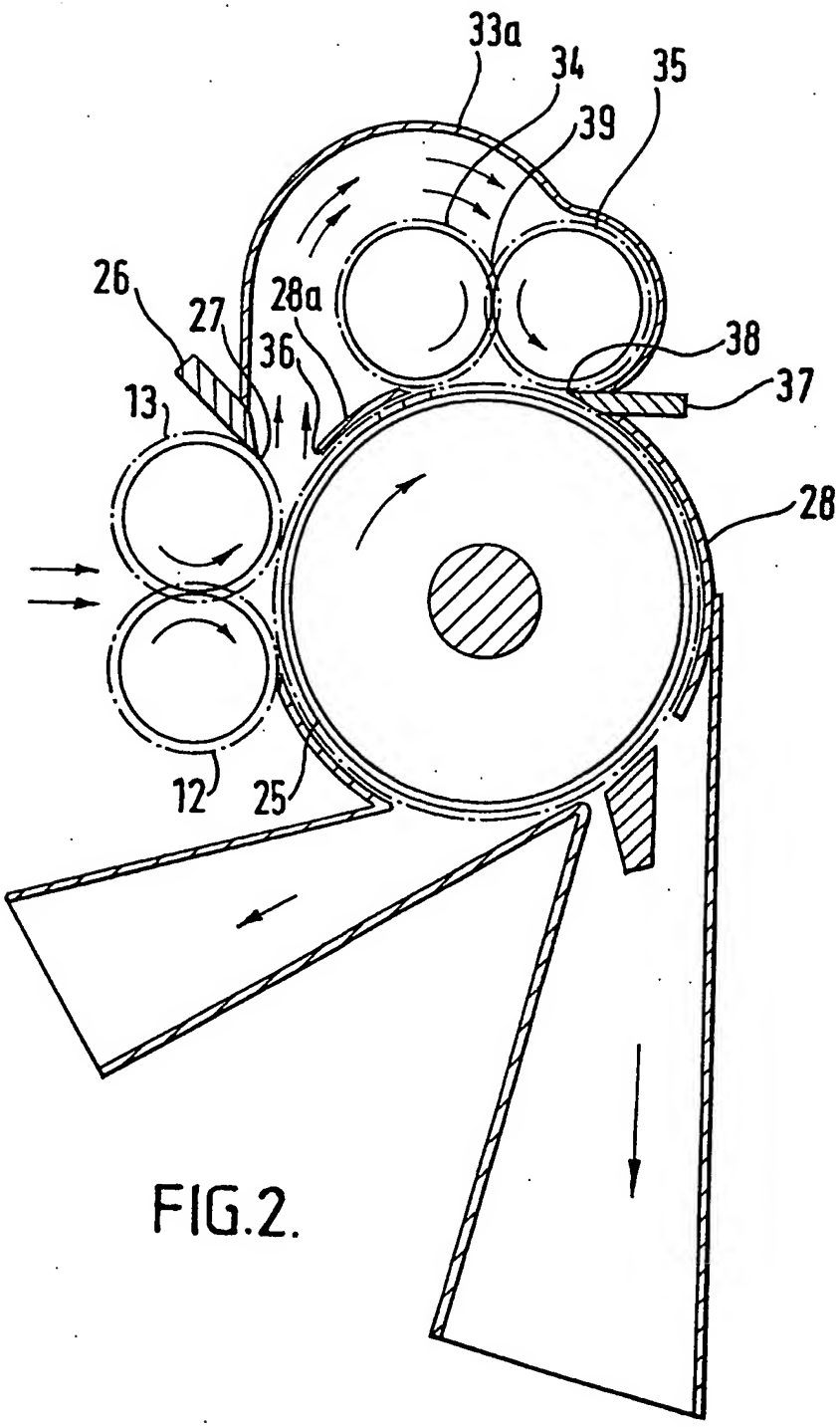

FIG.2.